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AD _____

RDT&E PROJECT NO _____

USATECOM PROJECT NO 8-6-7310-01

USAIB PROJECT NO 3152

MILITARY POTENTIAL TEST OF
HANDHELD INFANTRY RANGE FINDER (RAC-RANGER)

FINAL REPORT

BY

PSGT LAWRENCE C. LACKEY, JR.

3 JUNE 1966

DEPARTMENT OF THE ARMY
UNITED STATES ARMY INFANTRY BOARD
FORT BENNING, GEORGIA 31905

13 SEP 1966

AMSTE-BC

SUBJECT: Final Report, Military Potential Test of Handheld Infantry Range Finder (RAC-Ranger), USATF COM Project No. 8-6-7310-01


c. The principle of superimposing the proper sized, range calibrated silhouette image over a target to establish range does not have military potential for infantry use.

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13 SEP 1966

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Washington, D. C. 20315
Commanding General, USA Combat Developments Command, ATTN:
CDC Liaison Officer, USATECOM, Aberdeen Proving Ground,
Maryland 21005

1. Subject report has been approved by this headquarters. Copies are furnished for review.

2. Test Results:

a. Range and Accuracy:

(1) Under optimum conditions the best results obtained reflected a 15.4% spread exceeding the essential (7%) and desirable (2%) margin of error permitted by the SDR.

(2) A spread averaging 16% of range was found when target soldiers differed 10 inches in height.

b. Human Factors:

Observers were unable to match images to target soldiers and to interpolate precisely enough to obtain acceptable accuracy.

3. Conclusions:

a. Based on range and accuracy results the principle of superimposing a silhouette image over a target was not considered compatible with the skills and aptitudes of soldiers.

b. The need for range determination in fire planning prior to the appearance of a target soldier goes unfulfilled with an instrument involving the principle of superimposing a silhouette image over a target soldier.

DEPARTMENT OF THE ARMY
UNITED STATES ARMY INFANTRY BOARD
Fort Benning, Georgia 31905

STEBC-SW (P-3152)

19 SEP 1966

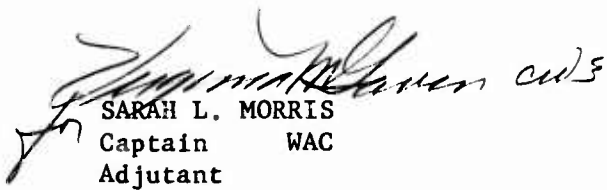
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USATECOM PROJECT NO 8-6-7310-01

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MILITARY POTENTIAL TEST OF
HANDHELD INFANTRY RANGE FINDER (RAC-RANGER)

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3 JUNE 1966

DEPARTMENT OF THE ARMY
UNITED STATES ARMY INFANTRY BOARD
FORT BENNING, GEORGIA 31905

ABSTRACT

1. Test Purpose and Background. The Military Potential Test of the Handheld Infantry Range Finder (RAC-Ranger) was conducted to determine the military potential value of superimposing and/or interpolating test reticle images with combat type targets as a method of range determination. On 15 April 1966 US Army Test and Evaluation Command directed the original plan of test be changed to delete all portions of the test that required range estimation and weapons firing.

2. Test Location and Duration. Testing was accomplished at Fort Benning, Georgia, from 27 April to 4 May 1966.

3. Test Method. The Handheld Infantry Range Finder (RAC-Ranger) was tested under field conditions similar to those expected during its normal use and reticle images were superimposed on combat type targets.

4. Summary of Pertinent Findings, Conclusions, and Recommendations.

a. Findings. During the test it was found that even under optimum conditions the margin of error and the range spread of this concept are greater than the maximum allowable by the current Small Development Requirement (SDR).

b. Conclusion. The US Army Infantry Board concludes that the principle of superimposing the proper sized, range calibrated, silhouette image over a target to establish its range does not have military potential for infantry use.

c. Recommendation. The US Army Infantry Board recommends that no further consideration be given the principle of superimposing the proper sized, range calibrated, silhouette image over a target to establish its range.

FOREWORD

The US Army Infantry Board (USAIB) was responsible for preparing the test plan, test execution, and preparing the test report.

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SECTION 1. INTRODUCTION

1.1 BACKGROUND

Experience indicates that a deficiency exists in the ability of forward observers, antitank weapons crewmen and small unit leaders to accurately estimate ranges. Research efforts since 1926 have failed to reveal a suitable range finder for infantry use. Previous range finders which operated on the stadia principle required a target of known dimensions, and such targets were not always available. A range finder concept using the stadiametric principle, but not requiring the operator to know or to index the target size into the instrument, is the subject of a current study. To evaluate this concept, a range finder has been fabricated which uses a reticle presenting a series of numbered silhouettes representing a soldier. This range finder has been subjected to limited feasibility testing and was made available to the US Army Infantry Board (USAIB) for this military potential test.

1.2 DESCRIPTION OF MATERIEL

The Handheld Infantry Range Finder (test range finder) is a 4.8 power elbow telescope used in US Army cinetheodolites and employs the stadiametric principle for range determination. This device is not intended to represent the configuration of a range finder but is intended merely as a vehicle with which to evaluate this concept. Sketches of the reticle silhouette patterns (images) provided with the test range finder are shown in Figure 1, page 2.

1.3 OBJECTIVE

To determine whether the principle of superimposing the proper sized, range calibrated, silhouette image over a target to establish its range has military potential.

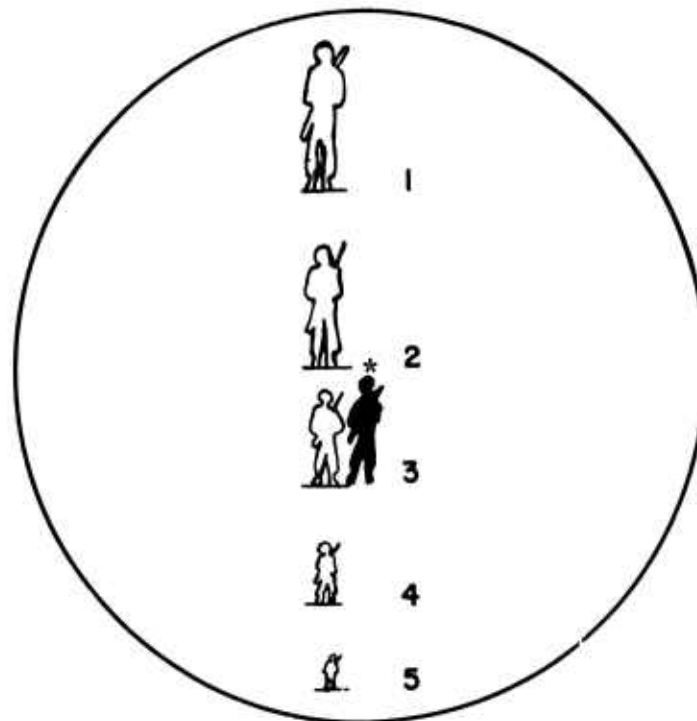
1.4 SUMMARY OF RESULTS

1.4.1 Preoperational Inspection and Physical Characteristics (Subtest No 1)

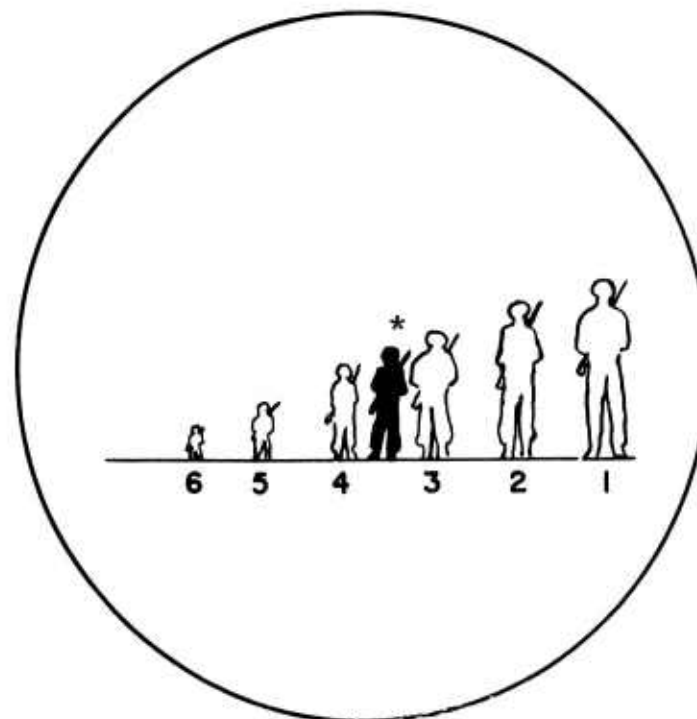
The test range finder was found to be complete and operable. No carrying case was provided.

1.4.2 Range and Accuracy (Subtest No 2)

1.4.2.1 Under optimum conditions, the best results obtained reflected a 15.4% spread. This exceeded the essential (7%) and desirable (2%) margin of error permitted by the SDR and was considered unacceptable.



VERTICAL ARRAY
Interpolation 2.5 Value



HORIZONTAL ARRAY
Interpolation 3.5 Value

Figure 1. Reticle Silhouette Patterns (Images)

* The darkened silhouette is not a part of the reticle, but when the target soldier is in this position, the interpolated value is as shown above.

1.4.2.2 A spread averaging 16% of the range was found when target soldiers differed 10 inches in height. This error was inherent in this concept, exceeded the maximum allowable, and was considered unacceptable.

1.4.2.3 An error of 10% in image interpolation at 1,500 meters resulted in a range error of approximately 150 meters. A silhouette image that would approximate the height of a target soldier at 1,500 or 2,000 meters would be so small that the margin of error would be even greater.

1.4.3 Human Factors Engineering (Subtest No 3)

1.4.3.1 The principle of superimposing a silhouette image over a target in an attempt to establish its range required no specialized training.

1.4.3.2 Since observers were unable to match images to target soldiers and to interpolate precisely enough to obtain acceptable accuracy, this principle was not considered compatible with the skills and aptitudes of soldiers.

1.5 CONCLUSION

The US Army Infantry Board concludes that the principle of superimposing the proper sized, range calibrated, silhouette image over a target to establish its range does not have military potential for infantry use.

1.6 RECOMMENDATION

The US Army Infantry Board recommends that no further consideration be given the principle of superimposing the proper sized, range calibrated, silhouette image over a target to establish its range.

SECTION 2. DETAILS OF TEST

2.1 INTRODUCTION

2.1.1 Test Criteria

The test range finder was tested against the applicable requirements of the Draft Proposed Small Development Requirement (SDR) for a Simple, Optical, Handheld Range Finder.

2.1.2 Test Soldiers

All test soldiers involved in this military potential test were instructed as to the objectives of the test and the operation, functioning, and maintenance of the test item. Soldiers used during the test were representative of those who will operate and maintain the test item in Army units. When appropriate, test soldiers were equipped with combat uniform and equipment.

2.1.3 Test Location and Duration

Testing was conducted at Fort Benning, Georgia, during the period 27 April through 4 May 1966.

2.1.4 Photographic Coverage

Photographic coverage was used where appropriate to supplement data obtained during this test.

2.1.5 Qualitative Observations

Where appropriate, qualitative observations and judgments of experienced personnel concerning the performance or suitability of the test range finder were clearly indicated as such and recorded separately from factual data. Such observations and judgments were employed to expand upon factual data and were limited to the scope of the test.

2.1.6 Safety Release

No safety release was required for the test range finder.

2.1.7 Control Item

All portions of the test requiring comparison with a control item were deleted.



Figure 2. Handheld Infantry Range Finder.

2.3 SUBTEST NO 2, RANGE AND ACCURACY

2.3.1 Objective

To determine the extent to which the test range finder met the following SDR:

"(Essential) This range finder must have a range spread of from 200-1500 meters; (desirable) 100-2000 meters. The rangefinder should provide accuracy with a margin of error not to exceed 7 percent of range (essential), 2 percent of range (desirable)."

2.3.2 Method

2.3.2.1 A target soldier, in the standing position, was positioned, in turn, at ranges of 100, 200, 300, 400, 500, 600, 700, and 1,500 meters from the observation point (OP). The test area was a relatively flat field with varying grass height and slight depressions at the various ranges so that in some instances the lower portion of the legs of the target soldier was not visible to the operators of the test range finder. Light conditions were generally overcast with occasional direct sunlight. Using both vertical and horizontal image arrays of the test range finder, four test soldiers (observers) located at the OP each estimated the degree to which the height of the images equaled the height of the target soldiers. The observers attempted to use the image with a number which corresponded to the actual range (e.g., image No 1 was superimposed on the target soldier when he was positioned at 100 meters from the OP). When it was found that a correlation between images and range could not be obtained, interpolation to the nearest tenth between images was attempted (e.g., if the height of the target soldier was three times that of image No 1, the value given was .3; and if the height of the target soldier was halfway between the height of image No 2 and image No 3, the value was 2.5). Since an image tall enough for use at 100 meters was not provided, no further tests were made at this range in subsequent exercises.

2.3.2.2 The exercises described in paragraph 2.3.2.1 were repeated with the target soldier moving by each of the following methods: crouching, crawling, walking, and running. Interpolation only to the nearest five tenths was attempted.

2.3.2.3 Two target soldiers were selected to represent the extremes of height variation among soldiers. The tallest man selected was 6 feet 1½ inches in height, combat dressed, and the shortest man selected was 5 feet 3½ inches in height, combat dressed. A photograph of the target soldiers appears in Figure 3, page 8. Each of three observers then directed the target soldiers to move until they were the exact distance required to match their height with the height of each image of the vertical array of the test range finder. In each case, the actual



Figure 3. Target Soldiers, 5 Feet 3½ Inches
and 6 Feet 1½ Inches in Height.

distance from the test range finder to the target soldier was then measured in meters. This exercise was repeated three times and the average distance to each target soldier was determined.

2.3.2.4 The times required for the test range finder operators to complete each operation in the exercises described in paragraphs 2.3.2.1 and 2.3.2.2 were noted.

2.3.2.5 To reduce error, the test range finder was placed on a stable platform for all operations.

2.3.3 Results

2.3.3.1 The 6-image horizontal array provided in the test range finder contained reticle images that approximated the height of target soldiers only at ranges of 300 to 700 meters; in using the horizontal reticle image array, standing target soldiers appeared larger than the largest image (image number 1) at all ranges up to approximately 300 meters. The 5-image verticle array contained reticle images that approximated the height of target soldiers only at ranges of 200 to 600 meters; in using the verticle reticle image array, standing target soldiers appeared larger than the largest image (image number 1) at ranges up to 200 meters. In Tables I through VI below, those values less than a whole number, or of the value unity, are the fractional part (nearest 1/10) of reticle image number 1 filled by the target soldier. Those values larger than 1 are the interpolated difference between the two reticle images used to measure range to the target soldier (i.e., 2.4 indicates the target soldier appeared shorter than image number 2, taller than image number 3, and was interpolated to a bit taller than an imaginary image, midsize between reticle image number 2 and reticle image number 3).

2.3.3.2 The results of each observer's attempt to match the height of the images with the heights of the standing target soldier, at the ranges indicated, are shown in Tables I and II:

TABLE II						
VERTICAL IMAGE ARRAY						
MATCHING OF IMAGES TO						
STANDING TARGET SOLDIER 6 FEET 1½ INCHES IN HEIGHT						
Observer	Ranges in Meters					
	100	200	300	400	500	600
No 1	.5	1.0	2.0	4.0	4.5	5.0
No 2	.5	1.0	2.0	4.0	4.5	5.0
No 3	.5	1.0	2.0	3.5	4.5	5.0
No 4	.5	1.0	2.0	4.0	4.5	5.0
Average	.5	1.0	2.0	3.9	4.5	5.0
Spread	0	0	0	.5	0	0
Percent Spread	0	0	0	12.8	0	0
Average Time In Seconds	3.5	4.5	4.0	4.0	12.0	5.1
Note: 1. Interpolation between images was made to the nearest five tenths. 2. The average time for observers to complete a ranging operation was 5.5 seconds.						

2.3.3.3 It was the opinion of the test personnel that at 1,500 meters the target soldier was too indistinct and filled too small an area of the smallest image for useful results to be obtained. Also, an image approximating the height of a target soldier at this range would be too small to use with any degree of accuracy.

2.3.3.4 It was the opinion of test personnel that obscuration by tall grass of the feet and legs of the target soldier had no significant effect on results obtained. In these cases, the upper torso of the target soldier was matched with the like portion of the image.

TABLE I							
HORIZONTAL IMAGE ARRAY							
MATCHING OF IMAGES TO							
STANDING TARGET SOLDIER 6 FEET 1½ INCHES IN HEIGHT							
Observer	Ranges in Meters						
	100	200	300	400	500	600	700
No 1	.3	.6	.9	2.4	3.0	3.9	5.
No 2	.4	.7	.9	2.3	3.1	4.0	6.
No 3	.3	.6	1.0	2.9	3.9	5.0	6.
No 4	.3	.7	1.1	3.0	4.0	5.0	6.
Average	.32	.65	.97	2.65	3.50	4.47	5.75
Spread	.10	.10	.20	.70	1.00	1.10	1.00
Percent Spread	31.2	15.4	20.6	26.4	28.6	24.6	17.4
Average Time In Seconds	7.5	7.5	8	17	17	11.5	15.5
<p><u>Note:</u> 1. Interpolation between images was made to the nearest tenth.</p> <p>2. The average time for observers to complete ranging operations was 12 seconds.</p>							

2.3.3.5 The results of each observer's attempt to match the height of the image with the height of the crouching and the crawling target soldiers at the ranges indicated are shown in Tables III and IV.

TABLE III						
HORIZONTAL IMAGE ARRAY						
MATCHING OF IMAGES TO						
CROUCHING TARGET SOLDIER 5 FEET 9½ INCHES IN HEIGHT						
Observer	Ranges in Meters					
	200	300	400	500	600	700
No 1	0	2.0	3.0	3.0	5.0	5.5
No 2	1.0	2.0	3.0	3.5	5.5	6.0
No 3	1.0	2.0	3.0	4.0	5.0	5.5
No 4	1.0	2.0	2.5	4.0	5.0	6.0
Average	1.0	2.0	2.9	3.6	5.1	5.8
Spread	0	0	.5	1.0	.5	.5
Percent Spread	0	0	17.2	27.8	9.8	8.6
Average Time						
In Seconds	8	10.5	10.8	12.8	13.0	15.8
<u>Note:</u> 1. Interpolation only to the nearest five tenths between images was attempted. 2. The average time for test soldiers to locate target and determine value was 11.8 seconds.						

TABLE IV						
HORIZONTAL IMAGE ARRAY						
MATCHING OF IMAGES TO						
CRAWLING TARGET SOLDIER 6 FEET 1½ INCHES IN HEIGHT						
Observer	Ranges in Meters					
	200	300	400	500	600	700
No 1	.5	1.5	4.0	4.5	5.5	6.0
No 2	.5	1.5	3.0	4.0	5.0	5.5
No 3	1.0	1.5	4.0	4.0	5.5	5.5
No 4	.5	1.5	3.5	4.0	5.0	5.5
Average	.62	1.5	3.6	4.1	5.2	5.6
Spread	.5	0	1.0	.5	.5	.5
Percent Spread	80.6	0	27.8	12.2	9.6	8.9
Average Time						
In Seconds	11.0	10.5	4.8	7.2	15.0	15.2
<u>Note:</u> 1. Interpolation only to the nearest five tenths between images was attempted. 2. The average time for test soldiers to locate target and determine value was 10.6 seconds.						

TABLE II						
VERTICAL IMAGE ARRAY						
MATCHING OF IMAGES TO						
STANDING TARGET SOLDIER 6 FEET 1½ INCHES IN HEIGHT						
Observer	Ranges in Meters					
	100	200	300	400	500	600
No 1	.5	1.0	2.0	4.0	4.5	5.0
No 2	.5	1.0	2.0	4.0	4.5	5.0
No 3	.5	1.0	2.0	3.5	4.5	5.0
No 4	.5	1.0	2.0	4.0	4.5	5.0
Average	.5	1.0	2.0	3.9	4.5	5.0
Spread	0	0	0	.5	0	0
Percent Spread	0	0	0	12.8	0	0
Average Time In Seconds	3.5	4.5	4.0	4.0	12.0	5.1
Note: 1. Interpolation between images was made to the nearest five tenths. 2. The average time for observers to complete a ranging operation was 5.5 seconds.						

2.3.3.3 It was the opinion of the test personnel that at 1,500 meters the target soldier was too indistinct and filled too small an area of the smallest image for useful results to be obtained. Also, an image approximating the height of a target soldier at this range would be too small to use with any degree of accuracy.

2.3.3.4 It was the opinion of test personnel that obscuration by tall grass of the feet and legs of the target soldier had no significant effect on results obtained. In these cases, the upper torso of the target soldier was matched with the like portion of the image.

2.3.3.6 The results of each observer's attempt to match the height of the image with the height of the walking and running target soldiers at the ranges indicated are shown in Tables V and VI.

TABLE V			
HORIZONTAL IMAGE ARRAY			
MATCHING OF IMAGES TO			
WALKING TARGET SOLDIER 6 FEET 1½ INCHES IN HEIGHT			
Observer	Ranges in Meters		
	350	450	650
No 1	2.0	4.0	5.5
No 2	1.5	4.0	5.5
No 3	1.5	3.0	6.0
No 4	1.5	3.0	5.0
Average	1.6	3.5	5.5
Spread	.5	1.0	1.0
Percent Spread	31.2	28.6	18.1
Average Time In Seconds	11.0	13.0	15.0
<u>Note:</u> 1. Interpolation only to the nearest five tenths between images was attempted. 2. The average time for test soldiers to locate target and determine value was 13 seconds.			

TABLE VI			
HORIZONTAL IMAGE ARRAY			
MATCHING OF IMAGES TO			
RUNNING TARGET SOLDIER 5 FEET 9½ INCHES IN HEIGHT			
Observer	Ranges in Meters		
	350	450	650
No 1	2.0	4.0	4.5
No 2	2.0	4.0	5.5
No 3	2.0	3.5	5.0
No 4	1.5	3.5	5.0
Average	1.9	3.8	5.0
Spread	.5	.5	1.0
Percent Spread	26.3	13.2	20.0
Average Time In Seconds	3.8	5.5	5.8
<u>Note:</u> 1. Interpolation only to the nearest five tenths between images was attempted. 2. The average time for test soldiers to locate target and determine value was 5.3 seconds.			

2.3.3.7 The actual ranges at which each observer determined the height of the images, numbered as indicated, coincided with the height of the target soldiers, are shown in Table VII. The average of the ranges obtained by all observers is shown in Table VIII.

TABLE VII

EFFECT OF HEIGHT VARIATION OF TARGET SOLDIER ON ACCURACY										
Observer	Target Height 6 Feet 1½ Inches					Target Height 5 Feet 7½ Inches				
	Image Numbers					Image Numbers				
	1	2	3	4	5	1	2	3	4	5
No 1	*305	368	410	474	569	286	314	353	400	454
No 2	290	381	406	458	496	291	322	354	380	405
No 3	314	374	450	510	574	287	320	370	394	438
Average	303	374	422	481	546	288	319	359	391	432
* Range in meters.										

TABLE VIII

AVERAGE EFFECT OF HEIGHT VARIATION OF TARGET SOLDIER ON ACCURACY					
Image No	6'1½" Target Estimated Average Range in Meters	5'3½" Target Estimated Average Range in Meters	Estimated Average Range Both Targets in Meters	Spread in Meters	Spread as a Percent of Average Range
1	303	288	295.5	15	5.1%
2	374	319	346.5	55	15.9%
3	422	359	390.5	63	16.1%
4	481	391	436.0	90	20.6%
5	546	432	489.0	114	23.3%

2.3.4 Analysis

2.3.4.1 By operating the test range finder on a stable platform and by using the standing target soldier, the observer is provided the most favorable opportunity possible to obtain precise measurements. It is immediately apparent that the test range finder is not calibrated; also, the width of the silhouette images does not approximate the width of target soldiers when the image and target coincide in height. Assuming that the height of the images are calibrated to accurately reflect changes in range, the results obtained (Table I) reveal that under these optimum conditions, the best results that could be obtained reflect a 15.4% spread (at 200 meters). This exceeds the essential (7%) and desirable (2%) margin of error permitted and is unacceptable.

2.3.4.2 The comparison of the average time required by test soldiers to obtain readings shows that the test soldier can much easier interpolate to a .5 than to a .1 value.

2.3.4.3 When interpolating to the nearest .5 value, target soldier standing (Table II), the results are much more consistent; however, the .5 value at 100 meters is equal to a 50% error or 50 meters, and a .5 value at 600 meters is equal to an 8.3% error. This error is inherent in this concept and is in addition to any operator error.

2.3.4.4 The results obtained with crouching, crawling, walking, and running target soldiers also do not approach the accuracy requirements.

2.3.4.5 A spread averaging 16% of the ranges tested is found when target soldiers differ 10 inches in height. If the test range finder were calibrated to a height, midway between 6 feet 1½ inches and 5 feet 3½ inches, an average 8% margin of error would be present. This error (which is in addition to any operator error) is inherent in this concept, exceeds the maximum allowable, and is unacceptable.

2.3.4.6 An error of 10% in image interpolation at 1,500 meters results in a range spread of approximately 150 meters. A reticle image that would approximate the height of a target soldier at 1,500 or 2,000 meters would be so small that the margin of error would be even greater.

2.3.4.7 The test range finder does not meet the range spread or accuracy requirements.

2.4 SUBTEST NO 3, HUMAN FACTORS ENGINEERING

2.4.1 Objectives

2.4.1.1 To determine the compatibility of the concept of the test range finder with the skills, aptitudes, and limitations of soldiers.

2.4.1.2 To determine the extent to which the test range finder met the following SDR:

"(Essential) The range finder must be such that the individual will require no specialized training in its use other than a short period of familiarization."

2.4.2 Method

2.4.2.1 Five observers received 30 minutes of instruction. They were required to practice matching of images to target soldiers at various ranges. A thorough explanation of interpolation was given. Practice range readings were critiqued by the instructor.

2.4.2.2 This subtest was conducted concurrently with all test activities.

2.4.3 Results

2.4.3.1 After 15 minutes of instruction and 15 minutes practical work, all observers understood the principle of operation of the test range finder and how to interpolate values.

2.4.3.2 The results obtained when test soldiers attempted to match images to targets and to interpolate between images were reported in Subtest No 2, Range and Accuracy.

2.4.4 Analysis

2.4.4.1 The principle of superimposing an image over a target to establish its range requires no specialized training.

2.4.4.2 Since observers are unable to match images to target soldiers and to interpolate precisely enough to obtain acceptable accuracy, the principle is not considered compatible with the skills and aptitude of soldiers.

SECTION 3. APPENDICES

APPENDIX I. REFERENCES

1. Letter, Research Analysis Corporation, 10 December 1965, with 2 inclosures.
2. Letter, AMSTE-BC, USATECOM, 13 January 1966, subject: "Test Directive for Military Potential Test of Handheld, Infantry Range Finder (RAC-Ranger), USATECOM Project No. 8-6-7310-01," with inclosure 1, as revised.
3. Letter, AJIIS-I, USAIS, 19 January 1966, subject: "Draft Proposed Small Development Requirement (SDR) for a Simple, Optical, Handheld Range Finder," with 1 inclosure.
4. USATECOM Project No 8-6-7310-01, USAIB, February 1966, Plan of Military Potential Test of Handheld Infantry Range Finder (RAC-Ranger).
5. Letter, AMSTE-BC, USATECOM, 15 April 1966, subject: "Plan of Military Potential Test of Handheld Infantry Range Finder (RAC-Ranger), USATECOM Project No. 8-6-7310-10," with 1 inclosure.
6. Letter, AMSTE-BC, USATECOM, undated, subject: "Plan of Military Potential Test of Handheld Infantry Range Finder (RAC-Ranger), USATECOM Project No. 8-6-7310-10," with 2 inclosures.